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National Eutrophication Survey, Corvallis, Oreg

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REPORT

ON

CLARK CANYON RESERVOIR

BEAVERHEAD COUNTY

MONTANA

EPA REGION VIII

WORKING PAPER No. 791

WITH THE COOPERATION OF THE

MONTANA DEPARTMENT OF HEALTH & ENVIRONMENTAL SCIENCES

AND THE

MONTANA NATIONAL GUARD

MAY, 1977

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

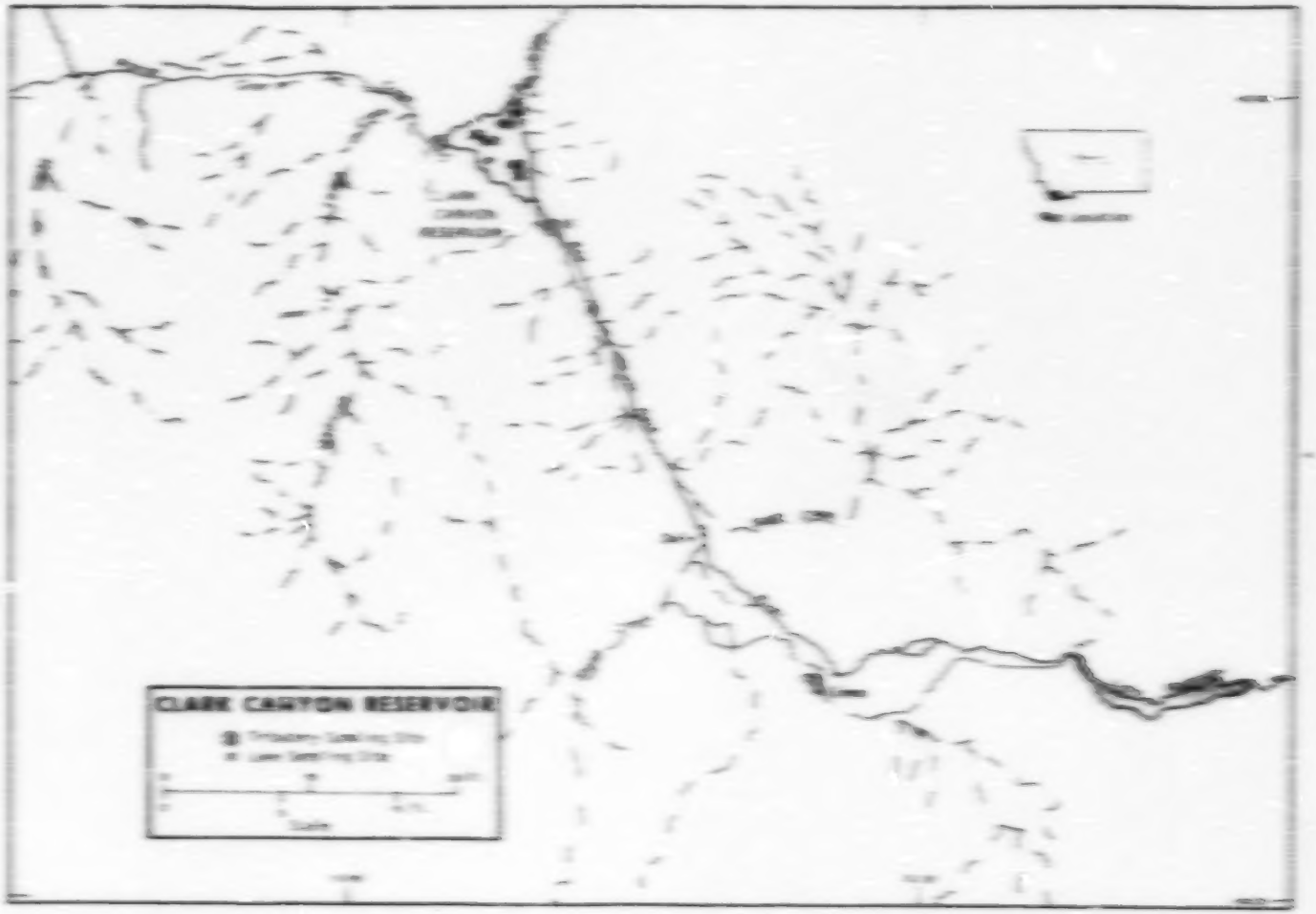
The staff of the National Eutrophication Survey (Office of Research & Development, U.S. Environmental Protection Agency) express sincere appreciation to the Montana Department of Health and Environmental Sciences for professional involvement, to the Montana National Guard for conducting the tributary sampling phase of the Survey, and to those Montana wastewater treatment plant operators who voluntarily provided effluent samples.

The staff of the Water Quality Bureau provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General John J. Womack, the Adjutant General of Montana, and Project Officer Major William Yeager, who directed the volunteer efforts of the Montana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY
STUDY LAKES AND RESERVOIRS
STATE OF MONTANA

LAKE NAME	COUNTY
Canyon Ferry	Broadwater, Lewis and Clark
Clark Canyon	Beaverhead
Flathead	Flathead, Lake
Georgetown	Deer Lodge, Granite
Hebgen	Gallatin
Koocanusa	Lincoln, MT; British Columbia, Can.
Mary Ronan	Lake
McDonald	Flathead
Nelson	Phillips
Seeley	Missoula
Swan	Lake
Tally	Flathead
Tiber	Liberty, Toole
Tongue River	Big Horn
Whitefish	Flathead
Yellowtail	Carbon, Bighorn, MT; Bighorn, WY


CLARK CANYON RESERVOIR

CLARK CANYON RESERVOIR
STORET NO. 3002

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Clark Canyon Reservoir is eutrophic. It ranked thirteenth in overall trophic quality when the 15 Montana lakes and reservoirs sampled in 1975 were compared using a combination of six parameters*. Thirteen of the water bodies had less median total phosphorus, 11 had less median inorganic nitrogen, 12 had less median dissolved orthophosphorus, five had less mean chlorophyll a, and ten had greater mean Secchi disc transparency.

Survey limnologists observed surface concentrations of algae in September and October as well as submergeo aquatic weeds at those times.

B. Rate-Limiting Nutrient:

Due to significant changes in the phosphorus concentrations in the samples, the algal assay results are not considered representative of conditions in the reservoir at the times of sampling.

The reservoir data indicate nitrogen limitation all four sampling times.

C. Nutrient Controllability:

1. Point sources--No known municipal or industrial point sources contributed phosphorus to Clark Canyon Reservoir during the sampling year. Septic tanks serving two shoreline campgrounds

* See Appendix A.

were estimated to have contributed less than 0.1% of the total phosphorus load, but a shoreline survey would be necessary to determine the significance of those sources.

The present phosphorus loading of 1.00 g/m^2/yr is greater than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 12).

2. Non-point sources--The phosphorus load from non-point sources, including precipitation, amounted to 99.9% of the total load reaching the reservoir during the sampling year. The Red Rock River added 47.5% of the total phosphorus load; Horse Prairie Creek, 37.4%; and the ungaged tributaries added an estimated 13.3%.

The non-point phosphorus export rates of the Red Rock River and Horse Prairie Creek were 2 and 6 kg/km^2/yr, respectively (see page 11). These rates are comparatively low; the mean rate of 37 gaged and sampled Montana tributaries was 8 kg/km^2/yr.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 19.97 kilometers^2.
2. Mean depth: 15.8 meters.
3. Maximum depth: 45.1 meters.
4. Volume: 315.526 x 10^6 m^3.
5. Mean hydraulic retention time: 1.0 years (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Red Rock River	4,006.7	6.65
Horse Prairie Creek	1,320.9	3.08
Minor tributaries & immediate drainage -	663.8	0.45
Totals	5,991.4	10.18

2. Outlet -

Beaverhead River	6,011.4**	9.79

C. Precipitation***:

1. Year of sampling: 43.0 centimeters.
2. Mean annual: 28.5 centimeters.

† Table of metric conversions--Appendix B.
†† Rawlings, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of reservoir.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Clark Canyon Reservoir was sampled four times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at three stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first, third, and fourth visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 27.1 meters at station 1, 9.4 meters at station 2, and 7.6 meters at station 3.

The sampling results are presented in full in Appendix D and are summarized in the following table.

[illegible] OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR LAKE CHAMPLAIN STATION
[illegible]

1ST SAMPLING : 5/28/75

3 SITES

PARAMETER	RANGE	MEAN	MEDIAN
TEMP (C)	6.2 - 7.4	7.2	7.2
TDSS DRY (MG/L)	6.2 - 6.4	6.4	6.4
DISCTHY (MICHOMO)	37[illegible] - 38[illegible]	37[illegible]	37[illegible]
PH (STAND UNITS)	8.1 - 8.3	8.2	8.1
TOT ALK (MG/L)	23[illegible] - 38[illegible]	27[illegible]	27[illegible]
TOT P (MG/L)	0.023 - 0.062	0.033	0.025
ORTHO P (MG/L)	0.031 - 0.032	0.031	0.029
NO2+NO3 (MG/L)	0.109 - 0.118	0.112	0.110
AMMONIA (MG/L)	0.059 - 0.078	0.057	0.060
KJEL N (MG/L)	0.468 - 0.788	0.558	0.558
INORG N (MG/L)	0.759 - 0.799	0.394	0.179
TOTAL N (MG/L)	0.514 - 0.825	0.662	0.665
CHLRPYL A (UG/L)	1.0 - 1.0	1.1	1.0
SECCHI (METERS)	2.1 - 4.0	3.0	3.0

2ND SAMPLING : 7/31/75

3 SITES

PARAMETER	RANGE	MEAN	MEDIAN
TEMP (C)	6.6 - 15.0	14.4	15.3
TDSS DRY (MG/L)	1.0 - 1.0	1.0	0.0
DISCTHY (MICHOMO)	38[illegible] - 43[illegible]	41[illegible]	40[illegible]
PH (STAND UNITS)	8.7 - 8.3	8.2	8.3
TOT ALK (MG/L)	19[illegible] - 20[illegible]	19[illegible]	19[illegible]
TOT P (MG/L)	0.054 - 0.064	0.064	0.064
ORTHO P (MG/L)	0.036 - 0.062	0.046	0.053
NO2+NO3 (MG/L)	0.046 - 0.236	0.075	0.046
AMMONIA (MG/L)	0.038 - 0.125	0.064	0.105
KJEL N (MG/L)	0.389 - 0.788	0.517	0.589
INORG N (MG/L)	0.145 - 0.256	0.171	0.159
TOTAL N (MG/L)	0.448 - 0.828	0.592	0.549
CHLRPYL A (UG/L)	0.9 - 1.0	1.2	1.2
SECCHI (METERS)	2.8 - 3.2	3.1	3.2

3RD SAMPLING : 9/ 2/75

3 SITES

PARAMETER	RANGE	MEAN	MEDIAN
TEMP (C)	15.6 - 17.7	26.6	25.3
TDSS DRY (MG/L)	5.0 - 5.2	7.6	7.7
DISCTHY (MICHOMO)	42[illegible] - 47[illegible]	45[illegible]	42[illegible]
PH (STAND UNITS)	8.3 - 8.5	8.4	8.4
TOT ALK (MG/L)	25[illegible] - 31[illegible]	28[illegible]	29[illegible]
TOT P (MG/L)	0.035 - 0.111	0.059	0.049
ORTHO P (MG/L)	0.029 - 0.035	0.029	0.025
NO2+NO3 (MG/L)	0.029 - 0.050	0.032	0.025
AMMONIA (MG/L)	0.055 - 0.139	0.093	0.090
KJEL N (MG/L)	0.381 - 0.488	0.394	0.459
INORG N (MG/L)	0.040 - 0.178	0.075	0.075
TOTAL N (MG/L)	0.335 - 0.465	0.394	0.465
CHLRPYL A (UG/L)	3.0 - 7.0	5.0	5.2
SECCHI (METERS)	1.0 - 1.0	1.0	1.0

[redacted]

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/28/75	1. Chroomonas sp.	175
	2. Cryptomonas sp.	145
	3. Cyclotia sp.	87
	4. Schroederia sp.	58
	5. Nantzschia sp.	58
	Total	523
07/31/75	1. Schroederia sp.	371
	2. Anabaena sp.	53
	3. Chroomonas sp.	53
	Total	477
09/03/75	1. Aphanizomenon sp.	1,634
	2. Chroomonas sp.	218
	3. Cryptomonas sp.	145
	4. Schroederia sp.	36
	Total	2,033
10/20/75	1. Aphanizomenon sp.	327
	2. Chroomonas sp.	210
	3. Cryptomonas sp.	117
	4. Schroederia sp.	23
	Total	677

2. Chlorophyll A -

Sampling Date	Station Number	Chlorophyll A (ug/l)
05/28/75	1	1.0
	2	1.4
	3	1.4
07/31/75	1	1.2
	2	1.4
	3	0.9
09/03/75	1	3.9
	2	6.2
	3	7.5
10/20/75	1	2.4
	2	1.1
	3	1.1

C. Limiting Nutrient Study:

An apparent loss of phosphorus occurred in the algal assay samples between the times of collection and the beginning of the assays, and the results are not representative of conditions in the reservoir at the times the samples were taken.

The reservoir data indicate nitrogen limitation at all sampling stations and times. The mean inorganic nitrogen/orthophosphorus ratios ranged from 9/1 to 3/1, and nitrogen limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Montana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff month of June when two samples were collected. Sampling was begun in October, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Montana District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in kg/km^2/year, at stations B-1 and D-1 and multiplying the means by the ZZ area in km^2.

No known wastewater treatment plants impacted Clark Canyon Reservoir during the sampling year.

A. Waste Sources:

1. Known municipal - None
2. Known industrial - None

* See Working Paper No. 175.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Red Rock River	9,485	47.5
Horse Prairie Creek	7,465	37.4
b. Minor tributaries & immediate drainage (non-point load) -	2,655	13.3
c. Known municipal STP's - None	-	-
d. Septic tanks* -	6	<0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	350	1.8
Total	19,960	100.0

2. Outputs -

Reservoir outlet - Beaverhead River	11,775

3. Net annual P accumulation - 8,185 kg.

* Estimate based on two shoreline campgrounds; see Working Paper No. 171.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Red Rock River	223,690	55.2
Horse Prairie Creek	112,800	27.9
b. Minor tributaries & immediate drainage (non-point load) -	46,800	11.6
c. Known municipal STP's - None	-	-
d. Septic tanks* -	140	<0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	21,560	5.3
Total	404,990	100.0

2. Outputs -

Reservoir outlet - Beaverhead River	311,590

3. Net annual N accumulation - 93,400 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Red Rock River	2	56
Horse Prairie Creek	6	85

* Estimate based on two shoreline campgrounds; see Working Paper No. 175.
** See Working Paper No. 175.

I. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	1.00	0.41	20.3	4.7

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Clark Canyon Reservoir:

"Dangerous" (eutrophic loading)	0.78
"Permissible" (oligotrophic loading)	0.39

V. LITERATURE REVIEWED

Rawlings, A., 1975. Personal communication (reservoir morphometry). Bur. of Reclamation, Helena.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690. Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

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CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3851 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

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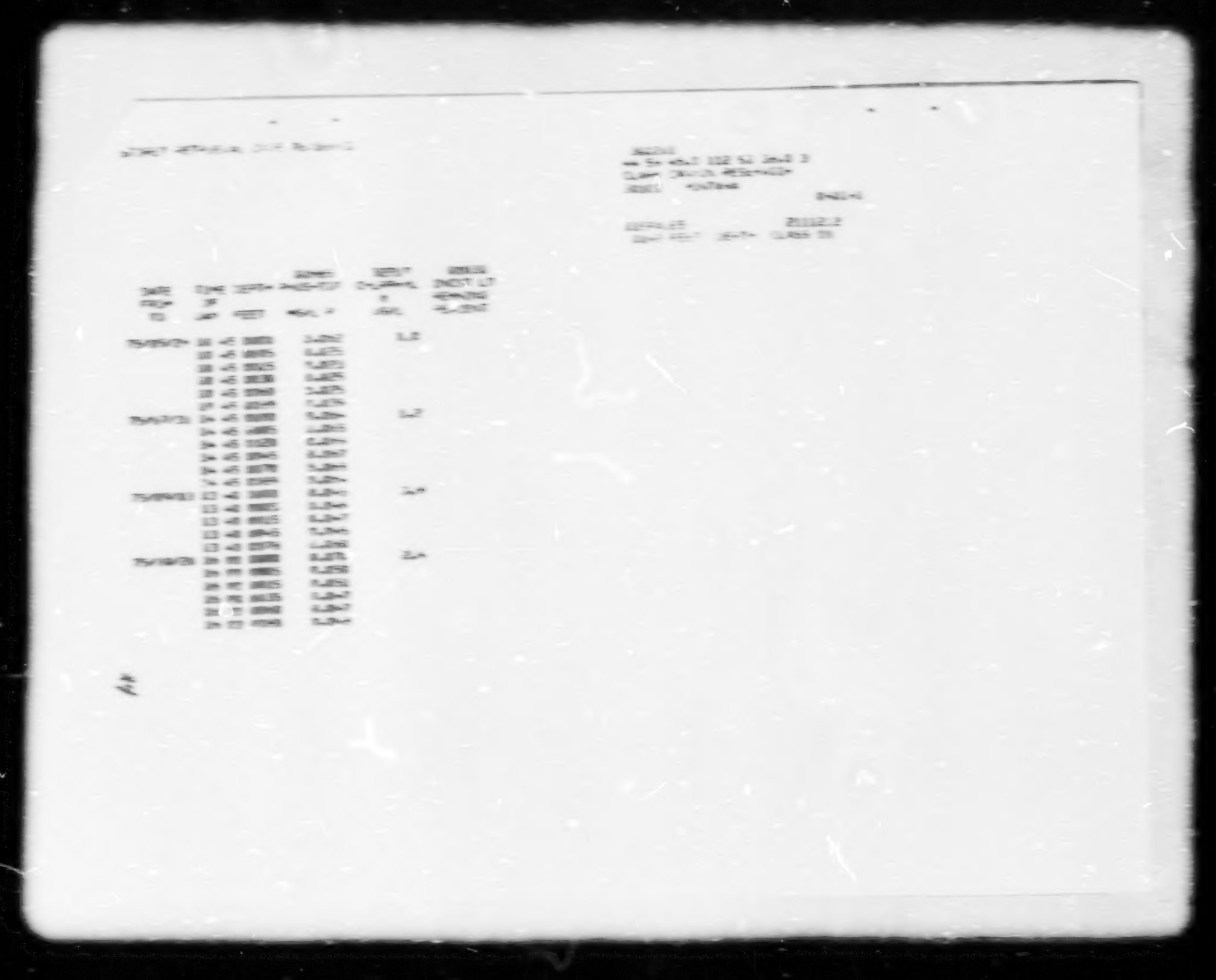
APPENDIX D

PHYSICAL and CHEMICAL DATA



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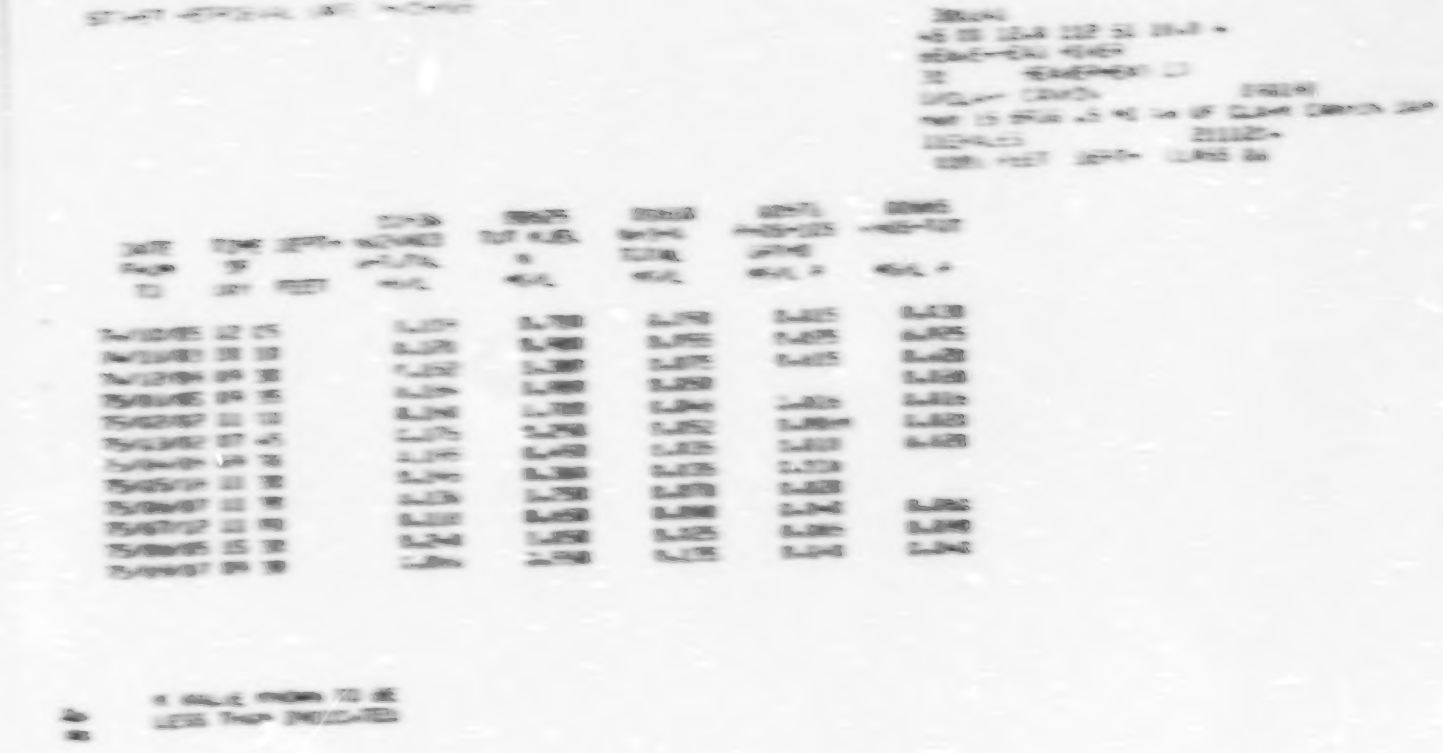
APPENDIX E

TRIBUTARY DATA



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